

SOURCE DETERMINATION OF OBSIDIAN FROM THE WESTFIELD (R11/898) SITE USING GEOCHEMICAL ANALYSIS

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Abstract. Non-artefact obsidian from the Westfield (R11/898) site was sourced using X-ray fluorescence (XRF) chemical analysis on seven flakes of unknown origin and selected geological samples of known source. Both qualitative and quantitative methods of clustering the unknowns indicates that the obsidian from this site comes from as few as two sources. Mayor Island is the most likely source of the green obsidian, and it is likely that most of the grey unknowns came from a Great Barrier Island source. Within the constraints of possible error, the idea of only two sources fits accepted theories on the origin of this raw material for temporary sites on the Auckland isthmus.

The results of the excavation of the Westfield (R11/898) site are outlined by Furey (1986). She concludes that this was a temporary camp within an area of gardening. An age range of 309 ± 59 to 421 ± 59 years B.P. is indicated by radiocarbon dating. Cultural remains occur in three main stratigraphic layers, and two occupation periods are recognised. A range of artefacts were collected, including a total of 626 obsidian pieces (forming some 52% of the lithic material, Furey 1986). This obsidian was classified according to colour, as shown in her Table 1, with the note that "... the green flakes are probably from Mayor Island and the grey obsidian is likely to be from several sources." (Furey 1986:18). This paper outlines an attempt to provide a more quantitative basis for the sourcing of this obsidian.

Sample selection

Two hundred and fifty two non-artefact pieces of obsidian from site R11/898 held at the Auckland Museum were used in this study. These pieces were assigned to one of the three designated stratigraphic layers, with 85 pieces having no layer assigned to them. A preliminary sort was then carried out on the basis of the series of hand specimen parameters shown on the flowchart of Moore (n.d.). In practice the colour (especially transmitted) was the major determining factor in this sorting process, mainly due to the small size of the obsidian pieces.

Two major considerations influenced the choice of samples to be analysed by the x-ray fluorescence (XRF) method:

(1) sample size, ideally 10 grams of material is required, this was rarely achieved in the given sample set.

(2) the method is destructive, thus the sample was on non-artefact material only.

The results of this preliminary sort, and the samples chosen for XRF analysis are shown in Table 1.

As a control on both elemental characterisation of the likely sources and the analytical method, obsidian from known localities, for which abundant sample was available, was also analysed. This was in response to the fact that only two of the samples to be sourced were of >10 g weight. By running multiple analyses of the known samples (including runs <10 g) the effect of lowered sample size (if any) could be assessed. The control rocks were taken from the reference collection of the Department of Anthropology, University of Auckland, and from two source areas:

- (i) Great Barrier Island (grey obsidian) — #680/4 (Te Ahumata), #679/26 (Awana), #2935; and,
- (ii) Mayor Island (green obsidian) — #504, #1514/2.

Mayor Island is a well documented source for green obsidian in New Zealand (Ward 1972). The Great Barrier Island source was suggested by Louise Furey (pers. comm.), and has been cited in the literature as a major obsidian source for the Auckland area (Fox 1982; Ward 1974).

Table 1. Preliminary sort and sample selection of obsidian flakes from the Westfield (R11/898) site.

	Sample size	Sample analysed	Percentage	
LAYER 1	64 pieces			OCCUPATION II
green	15 pieces	not suitable	(24.%)	
grey	49 pieces	#246 (12.7 g)	(76.6%)	
LAYER 2	20 pieces			OCCUPATION I
green	6 pieces	#54 (7.14 g)	(30%)	
grey	14 pieces	#66 (5.05 g)	(70%)	
LAYER 3	83 pieces			
green	23 pieces	#105 (5.14 g)	(27.7%)	
grey	60 pieces	#46 (11.28 g)	(72.3%)	
NO LAYER	84 pieces			
green	25 pieces	#444 (3.89 g)		
grey	59 pieces	#379 (6.66 g)		
Total sample size = 252, green = 69 (27.4%), grey = 183 (72.6%).				

Analytical procedure

The procedure used was that used for the geochemical analysis of rocks by the Department of Geology, University of Auckland. All the materials analysed were

selected for freshness, thus avoiding possible chemical changes (ie. clay formation) inherent in weathering processes. The analyses were carried out by the method of Norrish & Hutton (1969), using a Phillips PW 1410 x-ray spectrometer. Major elements (those generally occurring in abundances of >0.1 weight percent (wt %)) were analysed using glass discs consisting of sample powder and lanthanum flux. Those elements of lower abundance (reported as parts per million, or ppm) were analysed on boric acid backed discs of pressed powder. Analysis was run under the detection limits and instrumental settings as outlined by Parker (1983).

Results

The analytical results are presented in Table 2. The elemental weight percent values are also shown in Table 2, and can be used for direct comparison with the values presented by Duerden *et al* (1987, Table 1; see extract in Table 3) which were obtained by the PIXE/PIGME method. The relative percent errors between the control samples of differing aliquot weights were found to be within those listed in Parker (1983).

Comparison of the elemental weight percent values of the control analyses of this study with the corresponding values of Duerden *et al* (1987) shows a general lack of similarity, except for Ca, Sr, Zr, Y and Mn, and, Ti and Si (for Mayor Island only), with Rb from Great Barrier also similar to these workers. Unless gross rock chemical inhomogeneity (strangely affecting some elements and not others) can be used to explain this discrepancy, it would appear that the differences are due to differences in methodology. PIXE/PIGME is more sensitive to sample surface effects than XRF.

Sample 679/26 from Awana stands out, especially with respect to LOI and H₂O which total 7.02 weight percent. This may be explained by weathering processes, as volcanic glass (obsidian) is particularly vulnerable to hydration reactions. Thus this is the only sample which cannot be considered fresh — generally denoted by low LOI and H₂O values — and is thus not considered in the following attempts at sourcing.

Sources

The following sources are suggested by comparing the chemical data (known and unknown sources) presented in Table 2, and backed up by the corresponding values of Duerden *et al* (1987):

- (a) green obsidian pieces (#'s 54, 105, and 444) are sourced to the Mayor I 'green' source (control samples 1514/2 and 504);
- (b) grey pieces (#'s 49, 14, 60, and 59) are sourced to Great Barrier I (samples 680/4 and 2935).

As an additional quantitative comparison of this data, clustering analysis, utilising Euclidean distances, was employed. This technique supported the above conclusions with respect to source. The means and standard deviations of the two clusters are listed in Table 4, and provide a numeric summation of the raw data. Possible shortcomings include the small sample size, and it should be noted that the

Table 2. Analytical results of obsidian from the Westfield site.

Sample	680/4	679/26	2935	246
Major elements — wt. % (elemental wt. %)				
SiO ₂	75.79 (35.4)	70.95 (33.2)	75.96 (35.5)	75.69 (35.4)
TiO ₂	0.11 (659)	0.10 (599)	0.11 (659)	0.10 (599)
Al ₂ O ₃	12.80 (3.39)	12.72 (3.37)	12.57 (3.33)	12.59 (3.33)
Fe ₂ O ₃ *	1.47	1.67	1.42	1.37
MnO	0.03 (232)	0.04 (310)	0.03 (232)	0.03 (232)
MgO	0.17	0.12	0.15	0.20
CaO	0.75 (0.54)	0.75 (0.54)	0.69 (0.49)	0.68 (0.49)
Na ₂ O	3.83 (1.42)	2.31 (0.85)	3.94 (1.46)	3.80 (1.41)
K ₂ O	4.69 (1.95)	4.63 (1.92)	4.80 (1.99)	4.83 (2.01)
P ₂ O ₅	0.03	0.02	0.03	0.02
H ₂ O ⁻	0.03	1.02	0.18	0.15
LOI	0.13	6.00	0.16	0.41
Total	99.83	100.33	100.03	99.87
Trace elements (ppm)				
Ba	513.3	737.9	441.3	445.7
Rb	195.7	177.3	196.6	193.3
Sr	29.5	28.6	21.4	22.7
Pb	26.1	24.4	23.8	23.1
Th	21.4	15.7	25.0	18.3
Zr	142.0	194.3	132.3	133.6
Y	33.1	46.1	36.8	37.3
La	39.0	34.3	32.1	36.1
V	bdl	bdl	bdl	2.2
Cr	bdl	bdl	bdl	bdl
Ni	bdl	bdl	bdl	5.7
Cu	8.3	bdl	7.1	10.2
Zn	35.5	61.6	38.4	38.4
Sample	66	46	379	1514/2
Major elements — wt. % (elemental wt. %)				
SiO ₂	75.82 (35.4)	76.41 (35.7)	75.92 (35.5)	73.54 (34.4)
TiO ₂	0.11 (659)	0.12 (719)	0.10 (599)	0.23 (1379)
Al ₂ O ₃	12.62 (3.34)	12.70 (3.36)	12.88 (3.41)	10.48 (2.77)
Fe ₂ O ₃ *	1.43	1.42	1.45	4.74
MnO	0.02 (154)	0.03 (232)	0.03 (232)	0.10 (775)
MgO	0.16	0.18	0.23	0.06
CaO	0.69 (0.49)	0.68 (0.49)	0.76 (0.54)	0.21 (0.15)
Na ₂ O	4.01 (1.49)	3.88 (1.44)	3.90 (1.45)	5.84 (2.17)
K ₂ O	4.85 (2.01)	4.80 (1.99)	4.70 (1.95)	4.37 (1.81)
P ₂ O ₅	0.03	0.02	0.03	0.02
H ₂ O ⁻	0.11	0.02	0.04	0.02
LOI	0.18	0.15	0.29	0.00
Total	100.01	100.40	100.33	99.68

Table 2. Continued.

Sample	66	46	379	1514/2
Trace elements (ppm)				
Ba	383.8	436.9	480.3	bdl
Rb	194.5	194.7	195.4	132.4
Sr	21.8	22.2	30.8	bdl
Pb	25.6	22.7	23.8	26.3
Th	23.2	19.3	17.5	14.2
Zr	133.5	133.8	136.7	1015.7
Y	36.2	35.7	34.2	125.5
La	36.0	36.9	36.6	86.2
V	bdl	2.7	bdl	bdl
Cr	5.7	bdl	7.4	bdl
Ni	bdl	bdl	8.2	8.3
Cu	5.6	9.8	12.8	bdl
Zn	38.3	38.0	37.3	221.1
Sample	504	54	105	444
Major elements — wt. % (elemental wt. %)				
SiO ₂	74.36 (34.8)	72.27 (33.8)	73.74 (34.5)	75.53 (34.4)
TiO ₂	0.22 (1319)	0.22 (1319)	0.22 (1319)	0.20 (1199)
Al ₂ O ₃	10.60 (2.81)	9.75 (2.58)	10.51 (2.78)	9.69 (2.56)
Fe ₂ O ₃ *	4.56	5.93	4.47	5.46
MnO	0.09 (697)	0.13 (1007)	0.09 (697)	0.11 (852)
MgO	0.09	0.12	0.12	0.09
CaO	0.21 (0.15)	0.21 (0.15)	0.20 (0.14)	0.20 (0.14)
Na ₂ O	5.73 (2.13)	6.22 (2.31)	5.75 (2.13)	5.89 (2.19)
K ₂ O	4.44 (1.84)	4.28 (1.78)	4.40 (1.83)	4.39 (1.82)
P ₂ O ₅	0.02	0.03	0.02	0.02
H ₂ O ⁻	0.02	0.12	0.02	0.05
LOI	0.05	0.21	0.20	0.03
Total	100.40	99.48	99.75	99.67
Trace elements (ppm)				
Ba	bdl	bdl	49.8	bdl
Rb	133.2	130.5	131.2	142.4
Sr	2.1	bdl	bdl	bdl
Pb	26.2	26.7	25.6	27.3
Th	17.8	15.1	13.3	13.7
Zr	1001.8	1081.0	989.4	1171.2
Y	124.6	139.4	122.8	143.2
La	91.7	91.9	89.0	99.2
V	bdl	0.9	bdl	bdl
Cr	bdl	bdl	bdl	bdl
Ni	8.2	6.1	9.3	bdl
Cu	8.4	6.4	10.2	bdl
Zn	215.4	256.9	213.2	253.0

bdl = below detection limit. Fe₂O₃* = total iron reported as Fe₂O₃

Table 3. Values listed by Duerden *et al* (1987) for the source areas of this study.

Locality	Awana	Te Ahumata	Mayor I Green
SiO ₂	40	41	35
TiO ₂	480 — 730	420 — 620	1000 — 1500
Al ₂ O ₃	6.03 — 7.73	6.01 — 6.87	4.25 — 5.01
MnO	220 — 330	210 — 300	730 — 1060
CaO	0.45 — 1.16	0.37 — 0.62	0.06 — 0.17
Na ₂ O	1.56 — 3.12	2.48 — 2.74	3.61 — 4.09
K ₂ O	3.2 — 4.6	3.9 — 4.3	3.1 — 3.8
Trace elements (ppm)			
Rb	151 — 221	192 — 226	141 — 190
Sr	10 — 70	10 — 30	0 — 40
Zr	110 — 170	90 — 140	990 — 1200
Y	10 — 50	20 — 40	80 — 160

values in Table 4 for Ba, Sr, V, Cr, Ni and Cu are rather meaningless since they did not occur in concentrations above the detection limits for all samples. A further weakness of the Euclidean distance method is sensitivity to observation order. However, the clustering results were identical regardless of how the data was ordered.

Discussion

Although the original qualitative sort is open to error and the quantitative sourcing is of small sample size, a single source (Mayor I) for the green obsidian seems valid. The grey grouping, however, is not as easy to substantiate because, while some grey source groups can be eliminated as unlikely, a number of possible sources still exist in other clusters, as shown by Moore's (n.d.) chart. This lack of positive sourcing is accentuated by the small percentage (2.2%) of grey obsidian analysed in this study. Logically a Great Barrier I source would fit, being the closest source of obsidian to this site, but, as Seelenfreund-Hirsh (1985) asserts, distance to source may not have always been the primary determining factor. However, as Seelenfreund-Hirsh (1985) concludes, temporary sites (as site R11/898 most probably was) tend to have a smaller number of sources represented. The inference of only two sources may, therefore, best fit within the overall New Zealand situation.

The change in the relative importance of the two (?) sources with time provides a further point for discussion. Over time the total percentage of green obsidian changes — from 30.8% in Occupation I to 21.3% in Occupation II (Furey 1986, Table 1). No figures were calculated for this study due to the large percentage (33.8) of obsidian in the no layer category. Furey's findings are in line with the work of Leach & de Souza (1979), who note the relative reduction, with time, of obsidian from the Mayor I

Table 4. Cluster statistics — mean values and standard deviations (in brackets).

Cluster	1 = Great Barrier I		2 = Mayor I	
Major elements (wt. %)				
SiO ₂	75.93	(0.2533)	73.89	(1.1916)
TiO ₂	0.11	(0.0075)	0.22	(0.0110)
Al ₂ O ₃	12.69	(0.1245)	10.21	(0.4464)
Fe ₂ O ₃ *	1.43	(0.0339)	5.03	(0.6351)
MnO	0.03	(0.0041)	0.10	(0.0167)
MgO	0.18	(0.0293)	0.10	(0.0251)
CaO	0.71	(0.0366)	0.21	(0.0055)
Na ₂ O	3.89	(0.0758)	5.89	(0.1978)
K ₂ O	4.78	(0.0674)	4.38	(0.0594)
P ₂ O ₅	0.03	(0.0052)	0.02	(0.0045)
Trace elements (ppm)				
Ba*	450.22	(43.7560)	9.96	(22.2712)
Rb	195.03	(1.1343)	133.94	(4.8433)
Sr*	24.73	(4.2378)	0.42	(0.9391)
Pb	24.18	(1.3674)	26.42	(0.6301)
Th	20.78	(2.9376)	14.82	(1.7964)
Zr	135.32	(3.5841)	1051.82	(75.5082)
Y	35.55	(1.6059)	131.10	(9.4578)
La	36.12	(2.2498)	91.60	(4.8420)
V*	0.82	(1.2750)	0.18	(0.4025)
Cr*	2.18	(3.4249)	0.00	(0.0000)
Ni*	2.32	(3.6750)	6.38	(3.7519)
Cu*	8.97	(2.5367)	5.00	(4.7582)
Zn	37.65	(1.1327)	231.92	(21.2649)

* = may be invalid due to being bdl

source. They cite the discovery of new obsidian sources as contributing to this change, with the additional factor, noted by Seelenfreund-Hirsh (1985), being restriction of access due to the increase of warfare and territoriality in later prehistory.

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